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and offspring or both offspring of the same male parent. Possibly they are not related, but sing alike because the younger bird learned its song from the older, or both learned to sing from the same individual.

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THE BREEDING HABITS OF THE NORTHERN RAVEN IN PENNSYLVANIA

BY RICHARD C. HARLOW.

BORDERING on extinction as a Pennsylvania bird, a few widely scattered pairs of Northern Ravens still exist in the mountains of Snyder, Mifflin, Center, Blair, Clinton, Union, Juniata, Lycoming and Huntingdon Counties (definite breeding records.) It is highly probable that a few still linger in the wildest sections of Luzerne, Columbia, Montour, Northumberland, Wyoming, Sullivan, Bedford and Fulton Counties. I have obtained reliable information of the breeding of these birds in Wyoming and Sullivan Counties during the last ten years and have seen birds taken there, while on April 18, 1919, I saw an adult bird with food in its beak and closely pursued by Crows in Luzerne County. It is probable that there are more pairs left in Center County than elsewhere within the state with Huntingdon, Mifflin and Clinton Counties following closely.

As late as 1900 it was still a fairly common breeding bird in many of the counties named but the decrease during the last ten years has been very marked and unless rigid steps are taken for its preservation, it will be but a very few years before it follows the Wild Pigeon into the list of extinct Pennsylvania species.

The Raven is naturally a very shy species and will not stand the encroachment of civilization and in a number of instances I have known them to leave nests which had been used for generations, as soon as heavy lumbering took place in close proximity to them. In 1917 out of five previously used nests, only one

pair was present. In my investigations throughout the central Pennsylvania mountains, I have located no less than sixteen nesting places, all of which had been used for years but all of which had been totally deserted from two to five years before being located. All of these were absolutely authentic records as in each case the bulky nests were still present on the cliffs.

The number of birds shot can not be the most serious factor in their decrease though it undoubtedly must be considered. Neither can the collecting of their eggs. The writer has taken a number of sets in his studies but never save in the case of one pair in 1910 and 1911 has a second set been taken in the same year. In nearly every instance a second set of eggs was deposited within three weeks and the same number of eggs laid as the first nest contained. As but one brood is raised it can readily be seen that no decrease can be attributed to this factor. The main reason for their decrease is lumbering in the vicinity of their nests or the encroachment of civilization in the shape of too-frequently used roads, or houses being built too close to the cliffs they occupy. In nearly every case these conditions are followed by the disappearance of the birds.

Food. During the winter and early spring the Raven is largely omnivorous. I have known them to eat the buds of various trees when hard pressed for food. At this season, however, they feed largely upon refuse picked up about the various deer camps which are so numerous throughout this territory. Bits of fat, flesh adhering to old bones and skin and legs of deer, all of which are commonly left in the vicinity of these camps are greedily sought out. Corn fields on the edge of their mountain fastnesses are visited and any corn that may have been left, devoured. Any dead animal is a feast and I have observed five Ravens feeding on the carcass of a dead dog in the snow.

A fact that I do not believe is generally known is that these birds disgorge pellets after the custom of our Owls.¹ I have repeatedly picked up these pellets on their nesting and roosting ledges and found them during the spring to contain the indigestible

¹ See Hoffman, Auk 1920, p. 454. [Ed.]

portions of various species of insects (chiefly Coleoptera) with bones and fur of smaller rodents in several instances. In several nests I have climbed to when they held young birds, I have found remains of frogs and small garter snakes. In no instances have I noted the Raven destroying birds' nests or eggs in the manner of the Crow and the Grackle and as the bird will always be one of our rarest species there is every reason to urge that it be taken off the list of unprotected species in the state.

I am fully aware that there is a great divergence of opinion concerning the question as to whether birds remain mated for life. Nevertheless in the case of the Raven I am firmly convinced that such is the case. In the case of the male bird especially the species is one of striking individuality. One male of a pair which I have studied for four years is very fearless, very noisy and possesses a deep voice which may easily be distinguished from that of any other Raven. Another male of a pair I have visited four times is invariably silent, soaring once and then leaving the cliff entirely, never varying this procedure from year to year. Still another whose home I have visited three times always utters a note (in addition to the usual vocabulary) that is strikingly like a hoarse laugh "haw-haw-haw-haw." Then there is the striking individuality in nesting of certain pairs. One pair builds always in trees, several times nesting within a hundred yards of one of the finest and most typical cliffs I know. Another pair always uses a cliff surrounded by a splendid forest containing numerous tree sites. One thing is sure, in so far as my experience goes, a pair which one discovers nesting in a tree will always be found thereafter in trees and a pair which once chooses a cliff always remains true to their first choice. Other characteristics are evident also to prove the same birds present at the same nests years after year. One male always comes to meet me when I am yet a quarter of a mile away, taking the same course each year, another always warns the female with a low note and sneaks away over the back of the ridge. Females, likewise, possess the same striking individuality of voice and action as the males. Then in addition to the choice of nest sites as evidenced above, different females lay very distinct types of eggs which, as a rule run very true. One nest al-

ways contains very dark uniform eggs while another holds very lightly marked specimens with a pale bluish-green background. The first nest of the two just mentioned runs to very small eggs, scarcely larger than Crow's, while the second nest always holds large sized eggs. The number in the set does not hold as true, though certain pairs never lay over four eggs and commonly three while others run to four and five. However, this is a problem which seems to be largely controlled by the vitality of the female at the time of reproduction, i. e.—dependent upon her age and the abundance of food during the winter months.

COURTSHIP. Mating takes place during the first ten days in February. A bird occasionally roosts upon one of the old nesting ledges during the winter as is evident by excrement found there but this is by no means usual. The pair return to the cliff together usually the first week in February, at first only for a short visit each day, and later for several visits. A heavy storm at this time usually delays these visits for several days. At this time I have seen them go to the nesting ledge, the female usually alighting on the ledge and the male on a dead stub nearby and spend ten or fifteen minutes there. At this time they often soar together high up in the air with wing tips touching, the male always slightly above the female. At times he will give a wonderful display of his prowess on the wing, either dropping like a meteor for several hundred feet and fairly hissing through the air in the manner of the male Duck Hawk, or tumbling like a pigeon over and over. During this period also, I have found them perched close together high up in an old dead tree caressing each other with bills touching.

VOICE. At this time and during incubation they seem to have a more extended vocabulary than during the rest of the year. As I have already said the Raven shows great individuality in its notes while the voice of the male is much deeper and stronger than that of the female. During the period of courtship and incubation there are two distinct notes that I have not heard at any other time. One is a soft "crawk," which the male gives to the female when he is sitting near her while she is on the nest ledge or incubating. The other is a series of "crawks" given while

on the wing and with rarely a note best expressed by the syllables "ge-lick-ge-lee" given either between the "crawks" or still more rarely as a single note.

This note which I have never seen described has a metallic gurgle which does not carry very far. Then there is of course the usual "crruck" given either singly or repeated any number of times but very frequently repeated three times when the bird is alarmed. There is also a "crrroak" given by the male and often repeated four times as a form of song when undisturbed and near the nest, though it may be given singly. These last two notes are given either upon the wing or while perched. The usual wing note is the rolling guttural "crruck." As I have said before, nearly every Raven I have met has some note that is distinctive but the above are the usual types. I have also heard a very distinct hollow, sepulchral laugh "haw-haw-haw-haw." The note of the young is easily distinguished up to the age of at least six months as I have raised the young from the nest up until this time. It is a harsh "cawr" when in the nest, more like the note of a Crow than of a Raven. The young are very noisy and from sad experience in my home I can testify that their desire for food is insatiable and backed up by strong lungs from dawn till dark.

NESTING SITE. There are two distinct types of nesting site chosen here in Pennsylvania—the cliff site and the tree site (the cliff nests outnumbering the tree nests in the proportion of about eight to one. This may be more accentuated because of the present lack of large timber, but the fact remains that according to tradition of the oldest settlers in the vicinity of the nests, some of the cliff sites have been used for seventy years, long before the former great white pine forests were cleared.

One feature is almost invariably demanded by the cliff nesting Ravens and that is that the location be dark and well shaded. Usually the darkest available section of the cliff is selected where the ledges are shaded by hemlocks which often grow on the smallest ledge on the face of the cliff. Very frequently the nest will be placed under an overhanging tongue of rock so that it will be protected from above and I have yet to see a nest in use that is not sheltered either by trees or by an overhang. Their need for

this is made evident when it is realized that nest building is begun and egg laying often started in February, while these mountains are subject to some of their worst winter storms and I have seen the ledges covered with snow and ice as late as March 20. A nest examined on March 16, 1919, was completely draped by icicles frozen from the overhang above to the rim of the nest on three sides. The next year the birds moved to a pot hole where they were more safe. Probably eighty per cent of the cliff nests found have been in mountain gaps and passes on the west side of the gaps, probably because the best shaded cliffs occur on that side though in certain sections where the rock strata lie parallel with the ridge, they breed along the ridge at any well shaded point. The height of the cliff seems to be a secondary consideration to the shade, though rarely is a cliff with a straight drop of less than fifty feet chosen and they run from there up to two hundred feet. The nest is built either on a projecting shelf or ledge either large or small, where suitable protection is offered with distance from the ground a secondary consideration but usually on the ledge most difficult of access. I have found nests in a pot hole only eight feet down on a two hundred foot cliff and again only sixteen feet up from the bottom of a fifty foot ledge. The nesting ledge almost invariably is well up towards the top of the mountain, often on a cliff near the summit, so the birds have a clear outlook of the surrounding country for miles. In such a case the cliff may not be as high but there will be an almost perpendicular talus slope at the base of the cliff running almost to the foot of the mountain. I have never seen a nest on a ledge that had any vegetation on it.

In the case of the tree nesting Ravens, the first requisite they seem to demand is the highest available tree and the second is good cover in the very top of the tree. The tree nests are giant structures over four feet across and yet the birds conceal them so well in the very top of the tree that they are frequently very hard to see from the ground. Usually the wildest mountain swamp is chosen where there still remain some large white pines and hemlocks. I have never known of a tree nest of the Raven to be used two years in succession even though absolutely undisturbed and when young were reared in safety. The birds usually return

to the same swamp but the nest site may be shifted from a hundred yards to a mile or more. One pair brought out four young one year undisturbed and the next year shifted five miles out of the swamp into a heavily timbered gap but returned the following year into the original swamp. I feel sure this is more often the case than is usually supposed for I have known of other cases where birds have been absent from a swamp for a year or more and have later returned.

In the case of cliff nesting Ravens, the birds usually return to the same ledge, though some pairs are much more persistent than others in this respect. Others will return to the same cliff, but vary in the ledge chosen, sometimes nesting on one ledge for several years and then shifting to another. I am strongly convinced that some of these birds (possibly very old ones) do not breed every year. At least in a number of cases I have found the nest completed and both birds present through the breeding season and yet no eggs were laid though the birds exhibited every solicitude at the presence of intruders. In other cases I have known of nests being rebuilt each year and yet only one bird was present. It is possible that the nest in such instances may have been a blind but I cannot feel such was the case where visit after visit would have revealed both birds. A very striking example is given in the case of a pair of birds nesting only a few miles from my home at State College, Pa. Young birds were taken from this pair in 1909 and sets of eggs in 1910 and 1911. From 1911 to 1919 this nest was rebuilt each year and both birds were frequently found about it, but in all this stretch of time no eggs were laid in the nest. It is my theory that the female had become so old that she was infertile as Ravens had nested on this cliff for sixty years according to the oldest settlers. In the summer of 1918, the female was shot by a hunter and the following spring the male returned with a new mate, the old nest was rebuilt and three eggs were laid.

The Raven is essentially a solitary bird and the nests of different pairs are usually a considerable distance apart. The only pairs I know of which nest at all near to one another are six miles apart. I know of no bird which comes into direct contact with the Raven

during the breeding season but the Duck Hawk and as this species stands civilization better through nesting on higher cliffs than the average Raven it usually outlasts the latter. There seems to be a mutual respect between the two species and though they have occasional disagreements I have known them to nest on ledges only forty feet apart, the Raven having young while the Duck Hawk had eggs. Certainly there is no other bird which would brave the Duck Hawk's wrath.

Nest building varies much more according to the individuality of the pair than to the severity of the season. I have gathered together very carefully data for the three last seasons which should serve to exemplify pretty well all types of seasonal conditions found in central Pennsylvania. The season of 1919 could be called fairly normal. During 1920 deep snow lay in the mountains till April 1, while 1921 presented one of the earliest seasons in history. Nest building for the six pairs studied began as follows:

	1919	1920	1921
Pair A.....	Feb. 16	Feb. 20	March 1
Pair B.....	Feb. 17		Feb. 14
Pair C.....	Feb. 17	March 10	
Pair D.....	Feb. 7	Feb. 18	Feb. 14.
Pair E.....	Feb. 7	Feb. 15	Feb. 10
Pair F.....	March 1	Feb. 20	Feb. 20

When the above are averaged with all other data, it is evident that under normal conditions, nest building begins between February 7 and 15, though some individuals may postpone it much later. It may also be readily seen that in the case of this bird seasonal conditions influence it but little. Nest building is done almost entirely by the female. I have seen the male a few times carrying sticks but in each instance they were dropped on the ground near the ledge. On March 2, 1919, I watched a pair building for sometime. The female made four trips at intervals of from ten minutes to half an hour, carrying each time a beak full of deer hair which she placed in the nest as lining. The male constantly accompanied her flying close to her on all the trips and occasionally giving exhibitions of his aerial prowess for her benefit—once dropping over and over at least sixty feet in the air like a tumbler pigeon. Both birds croaked frequently in the vicinity of the nest, the female

in spite of the fact that her beak was apparently full of hair. The male always perched on a dead stub close to the nest while she worked the lining into the cup. One pair I have watched are usually silent in building but most pairs call to each other in the vicinity of the nest.

Nest building occupies a period of between fourteen and eighteen days. The nest is a huge yet neat structure always conforming in contour with the ledge or crotch on which it is placed. For instance, one pair built in 1919 on a very small ledge and the nest was quite small but in 1920 shifted into a large crack or pot hole, and the nest was a huge structure over four feet across. It is well built into the ledge, pot hole or crotch in which it is placed, sticks being wedged into all available cracks near the base of the nest. The tree nests are usually placed in a double or triple vertical crotch from seventy to over one hundred feet up,—nearly always the highest available strong crotch but in one instance a horizontal crotch four feet out on a large limb was used.

The base of the nest varies from little more than three feet to five feet in the largest nests with an average of almost four feet. The cavity averages a foot in diameter and six inches in depth, the depth varying considerably. In several nests, I have seen one side of the cavity was against the face of the cliff or an upright limb, far from the center of the base and with practically no rim on one side. Usually, however, it is a fairly symmetrical nest for so large a structure. The base is composed almost entirely of dead branches and sticks, freshly broken by the birds themselves. When built upon last year's nest, the freshly broken sticks make a sharp line of contrast where they are built upon the old excrement bespattered rim of the previous year. Some of these dead branches are over three quarters of an inch in diameter and over three feet long. Oak sticks seem to be most frequently used though hemlock, pine and chestnut often occur as well. Frequently freshly broken and budded twigs (usually birch) bruised by the beaks of the birds are found especially well up toward the rim. This was a constant feature of all nests found in 1920, probably because the deep snows covered nearly all piles of brush and dead fallen trees. A great number of dead sticks always fall to the ground

or are blown out in the building and the snow underneath the ledge or tree is covered with them.

The two most constant features of the cup lining are bark shreds and deer hair, the latter predominating when available. When using the old nest the birds tear out the top lining from the previous year which has been fouled by the young and throw it out of the nest so that nearly always one may find small tufts of deer hair on the ground nearby. The bark strips, shreds and fibres are obtained from dead trees, underneath the rough outer bark and they frequently use grape vines shreds as well. Some nests are lined almost entirely with white hair from the belly of the deer and some with red from the back, the birds using just what is available from the carcass. Outside of these main features the lining varies according to material available in the various localities. Tufts of hair from domestic cattle or from dogs as well as horse hair are frequently found. Bits of fur from the skunk, opossum and wild cat, sheep wool, bits of green moss scraped from the sides of rocks are all used by various pairs. I have found one nest heavily felted with material which the birds had been seen picking from an old felt hat and in another lining were bits of rope. Perhaps the most striking nest was one containing a heavy lining of deer hair and flourishing on one side of the cavity was the entire tail of a deer.

A period of several days intervenes between the completion of the nest and the laying of the first egg. This varies with different pairs between three days and a week. During this time the birds visit the nest together at intervals during the day, the female going on the nest and turning around much as a bird does when she is moulding the cup into the right form.

I am appending a table of the pairs previously tabulated to show the dates of the laying of the first egg for the three years noted under nest building:

	1919	1920	1921
	normal	very late	very early
Pair A.....	March 4	March 2	
Pair B.....	March 5		March 1
Pair C.....	March 5	April 5	
Pair D.....	Feb. 22	March 5	March 3
Pair E.....	Feb. 25	March 2	March 2.
Pair F.....	March 17	March 15	March 10.

Despite previously published surmises, egg deposition occurs *daily* until the set is complete. In severe weather the female remains on the nest from the time the first egg is laid, leaving only for short trips for food. Under ordinary conditions however, she covers the eggs only at night until the full number is laid.

The eggs vary in number from two to seven with the average set consisting of four or five. Sets of three are quite common and certain pairs never lay more than three or four eggs. Six is very rare while I have but one record each of sets of seven and two.

The eggs vary a great deal both in size and coloration, some being so small as to approach the largest type of eggs of the Crow. The ground color is a pale bluish green or light olive green, spotted, dashed, blotched, streaked or smeared with greenish brown, dark brown and sometimes fewer markings of purplish and black. Some types are so heavily marked that the ground color is almost obscured and the color is uniform owing to the density of the markings. Other eggs are streaked and scrawled lightly, resembling very greatly the common type of egg of the White-necked Raven.

The average size of eggs of the Northern Raven taken in Pennsylvania will run considerably smaller than that of eggs taken farther north. A series of nineteen eggs averages in millimeters 48.4 mm. by 32.5 mm with extremes of 51 mm. and 44.8 mm. in length and 34 mm. and 31 mm. in width.

The four sets (nineteen eggs) measure in millimeters as follows:

Set A.	Set B.	Set C.	Set D.
44.8 × 33	50 × 33	48.6 × 33	49.2 × 34
47 × 31	49 × 32.6	49.4 × 32.6	49 × 34
47 × 32	47 × 31.5	48 × 31	50 × 34
46 × 31.1	51 × 32.5	50 × 32.6	49 × 33
		50 × 31.1	51 × 32.6
			51.6 × 34.2

The period of incubation is twenty days. During this time the male feeds the female upon the nest but does not as a rule sit upon the eggs except in cold, stormy weather when the female leaves the nest for food.

As in the case of nearly all species I have studied where the female is fed on the nest, she leaves it two or three times

daily for exercise and short searches for food. Except when hunting for food, the male is usually found during incubation perched on some dead stub not far from the nest. In such cases he croaks a warning to the sitting female on the approach of an intruder and she often leaves the nest when a person is yet two hundred and fifty yards away. In some pairs, and especially if the male is not on guard, the female sits until one is within fifty yards of the nest but such cases can not be considered as typical. Tree nesting birds usually leave the nest as the tree is approached. Both birds usually soar well up in the air croaking while the nest is being inspected but where a prolonged stay is made in the vicinity of the nest they will frequently perch side by side on a dead tree well away from the nest or leave the vicinity entirely for half an hour or more. The male is much more fearless and demonstrative in his defense of the nest, if defense it may be called.

The young are fed by both birds and remain in the nest for a period of four weeks and when they finally leave can fly short distances fairly well. They are very noisy when food is brought. The rim of the nest and the surrounding rock or limbs are heavily bespattered with white, chalky excrement, the young turning up their tails to the edge of the nest and evacuating over it. In fact I have seen some cliff nests where the cliff was as heavily spattered as a Duck Hawk ledge.

The parents are quite fearless in defense of their home against other birds. Usually they pay no attention to the pestering of Crows but about the nest I have seen them several times pick out individual Crows from the harrassing flocks and drive them clear out of the valley, striking heavily with their beaks while the Crows squawked with fear. They easily drive off the Red-tailed and Broad-winged Hawks and these birds put up but a feeble defense when beset.

The young stay about the vicinity of the nest for a week or more after leaving it but soon scatter and one rarely sees the family parties so common in many closely related species. I have seen but one instance of flocking on January 7, 1917, when a flock of seventeen were counted in a wild mountain section—probably influenced by food conditions.

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